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QUALITY CHARACTERISTICS OF TAMIL NADU RICES

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The high yielding varieties though grown on a large scale in Tamil Nadu, do not possess the desired quality attributes. Among 25 varieties studied none is extra long; the dimentional distributions and other quality factors are very narrow. Based on 'normalized grain weight', only two varieties are superfine. Varieties represent all GT groups. Cooking time and swelling ratio cannot be considered as indices of rice quality. Among cooking quality parameters like the elongation ratio, elongation index, proportionate change and others, the first one seems to be better in indicating rice quality. The cooking quality characteristics of IR 50 is very poor.

Consumers judge the quality of rice mostly on its appearance particularly, the colour, size and shape and on its elongation during cooking. Millers and traders, on the other hand, prefer a variety capable of giving high total and head rice recovery. Though the former is governed by genetic make up, the latter is mostly determined by the pre-and post-harvest practices. Commercial classifications of rice are based on its size and shape (Anonymous, 1968; 1980). Recently Bhattacharya and Sowbhagya (1980), Bhattacharya et.al. (1982A) and Showbhagya et al.. (1984) after examining various classifications, proposed a new rice classification taking into consideration of the length, shape (length : breadth ratio) and 'normalised grain weight' (10w/L). Tenderness and cohesiveness are the attributes that are

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looked upon in cooked rice but they are mostly governed by the total (Juliano et. al., 1965) and insoluble (Manohar Kumar et. al., 1976; Bhattacharya et. al., 1978) amylose; the preference ratings for tenderness and cohesiveness differ among individuals even within a particular section of consumers and hence these attributes cannot be generalised for the entire State. Further as the amylose content has nothing to do with the water absorption of rice during cooking (Sowbhagya et. al., 1984) and as the protein content did not correlate with any of the characters (Indian Agricultural Research Institute, 1980) except probably showing a small negative correlation with amylose (Bhattacharya et. al., 1982B), these two constituents were not considered in this study. On the other hand since the gelatinization temperature (GT) of the variety seems to involve in the extent of quality change in parboiling processes (Mohandoss and Pillaiyar, 1982) besides the processing conditions (Pillaiyar and Mohandoss 1981A, 1981B), in areas like Tamil Nadu wherein about 90% of the rice consumed is after parboiling, GT is of prime consideration in rice quality.

The cooking time of rice is related to its surface area and practically independent of any intrinsic quality characteristics of rice (Sowbhagya et. al., 1984). As the increase in linear elongation without girthwise expansion is considered to be a desirable attribute, the dimentional changes after cooking had been studied in depth.

MATERIALS AND METHODS

Twenty five samples (Table 1) collected from the University and State Farms were cleaned through the blower and then shelled in the Satake Grain Testing Mill. The samples were of six months old at the time of analysis. The length (L) and breadth (B) of whole milled rice were determined with the aid of a graduated card board (Pillaiyar and Mohandoss, 1981B) and the thickness (T) with Mitutoyo dial caliper. Using alkali score values (Bhattacharya and Sowbhagya, 1972), the GT was determined (Bhattacharya et. al., 1982B). The rice was cooked by double pot excess water method (Bhattacharya and Sowbhagya, 1971) and the optimal cooking time (o.t.) determined by the glass-plate opaque core method of Ranghino (1966). Linear elongation, breadthwise and thicknesswise expansion of rice after cooking were determined by cooking 20 whole milled rices to o.t., transferring the cooked kernels to a petridish containing a filter paper inside the lid to absorb the condensed water, keeping in a moist chamber and measuring the length, breadth and thickness in a graduated card board (Pillaiyar and Mohandoss, 1981B). The elongation ratio (L cooked/L raw), elongation index (L:B cooked / L:B raw), the linear elongation (Le), breadthwise (Be) and thicknesswise (Te) expansions (increase of L or B or T over uncooked), were calculated from the above values. The Swelling ratio is the increase in volume of cooked (o.t., double pot excess water method) to uncooked rice. The proportionate change in the length / breadth ratio of kernel on cooking which is suggested as a precise measure of elongation (Indian Agricultural Research Institute, 1980) has been calculated using the formula,

$$\text{Proportionate change} = \frac{(L_f/B_f)-(L_i/B_i)}{L_i/B_i}$$

where L_f and B_f are length and breadth of the kernel after cooking and L_i and B_i are length and breadth of the kernel before cooking.

RESULTS AND DISCUSSION

i) Dimentional distribution :

Except TKM 9 (red pericarp), other varieties are with white pericarp. The data on the various characteristics are indicated in Table 1. None of the variety is tiny (<12 mg) and giant (>23 mg) in size but most of them are small (12-18 mg), the rest being big (18.1-23 mg) in size. Not even a single variety grown in Tamil Nadu is extra long (>7 mm). Two varieties (CO 25 and CR 1009) are short (<5 mm), six (IR 34, ADT 35, IR 50, IET 4786, IET 1722 and CR 224) long (6-7 mm) and the rest being medium in length. The shape of most of the varieties is quasislender (L:B 2.4 to 3.0) or bold (L:B 2.0 to 2.39); CO 25 and CR 1009 are round (L:B < 2.0) while IET 4786, IR 50 and ADT 35 are slender (L:B > 3.0). As thickness is an additive factor in deciding the appearance of the rice, this attribute is also taken into consideration in this study. The thickness of the varieties ranged from 1.4 to 1.8 mm. Based on L : B : T ratio (proposed) IET 4786, IR 50, ADT 35 and CR 224 can be classified as slender while eight varieties represent medium; the rest being bold (Table 2). Based on L:B:T ratio, Ponni which is preferred most in Tamil Nadu can be classified as bold only. TKM 9 also falls under this category; whereas varieties like IET 1722, ASD 15, PY 1, IR 20, ACM 5, and W. Ponni are a grade above Ponni. As per Ramiah and Balasubramanyan classifications (Anonymous, 1968 & 1980) which are commercially adopted in this country ADT 35, IET 4786, CR 224 and IR 50 are long slender/superfine and ADT 36, ASD 15, and IET 1722 are medium selender/fine, the rest being short bold/common, but based on the normalized grain weight [10 w/L, g/cm] which is highly significantly correlated with the water uptake by rice during cooking (Sowbhagya et. al., 1984), IET 4786 and IR 50 are superfiner, ASD 15, CR 224, Ponni and White Ponni are fine, rest being either common or coarse (Table 1).

ii) Gelatinization temperature :

Though it has been indicated that most Indian varieties have an intermediate to moderately high GT the former being by far predominant especially in the samples from north and west; the southern varieties show a fair number with moderately high GT (Bhattacharya et. al., 1980) the varieties now studied represent all GT groups (Table 3). IET 4786 (74.5°C) and IR 20 (74.3°C) have high GT and because of this, the quality change during parboiling will be minimum in these varieties as compared to CO 25, a low GT (63.3°C) variety (Mohandoss and Pillaiyar,

Table 1 Quality characteristics of certain varieties grown in Tamil Nadu

Variety	Duration (Days)	Length (L) mm	B eadth (B) mm	Thickness (T) mm	L:B	L:T	B:T	L:B:T	L:B / L:T	100br. rice weight g	Normalised grain weight 10 w/L (mg/cm)
1	2	3	4	5	6	7	8	9	10	11	12
ADT 31	105	5.2	2.6	1.7	2.00	3.06	1.53	1.18	0.65	1.72	33.1
ADT 33	110	5.7	2.6	1.7	2.19	3.35	1.53	1.29	0 65	1.98	34.7
ADT 34	107	5.4	2.6	1.7	2.08	3.18	1.53	1.22	0 65	1.78	33.0
ADT 35	135	6.5	2.1	1.5	3.10	4.33	1.40	2.07	0.72	1.78	27.4
ADT 36	110	5.7	2.2	1.5	2.59	3.80	1.47	1.73	0 68	1.64	28.8
ASD 15	125	5.0	2.0	1.4	2.50	3.57	1.43	1.79	0.70	1.21	24.2
CO 25	165	4.9	2.5	1.7	1.96	2.88	1.47	1.15	0.68	1.73	35.3
CO 37	115	5.3	2.2	1.7	2.41	3.12	1.29	1.42	0.77	1.72	32 5
CO 40	170	5.5	2.5	1.8	2.20	3.06	1.39	1.22	0.72	1.92	34.9
CO 42	140	5.5	2.5	1.7	2.20	3.24	1.47	1.29	0.68	1.93	35.1
TKM 9	105	5.5	2.7	1.7	2.04	3.24	1.59	1.20	0.63	1.88	34.2
TT 1444	105	5.5	2.4	1.7	2.29	3.24	1.41	1.35	0.71	1.80	32.7
IET 1722	105	6.1	2.1	1.6	2.90	3.81	1.31	1.81	0.76	1.91	31.3
IET 4786	100	6.3	1.8	1.5	3.50	4 20	1.20	2.33	0.83	1.37	21.7
GR 224	105	6.0	2.0	1.5	3.00	4.00	1.33	2.00	0.75	1.38	23.0
CR 1009	165	4.8	2.6	1.8	1.85	2.67	1.44	1.03	0.69	1.70	35.4
NLR 9672	150	5.3	2.5	1.7	2.12	3.12	1.47	1.25	0.68	1.83	34.5
PY 1	135	5.2	1.9	1.6	2.79	3.25	1.19	1.71	0.84	1.49	28.7
ACM 5	135	5.6	2.3	1.6	2.44	3.50	1.44	1.53	0.70	1.69	35.2
Ponni	140	5.0	2.3	1.5	2.17	3.33	1.53	1.45	0.65	1.25	25.0
W. Pooni	140	5.3	2.2	1.5	2.41	3.53	1.47	1.61	0.68	1.28	24.2
Kannagi	105	5.5	2.5	1.6	2.20	3.44	1.56	1 38	0.64	1.69	30.7
IR 20	135	5.7	2.3	1.5	2.48	3.56	1.44	1.55	0.70	1.64	28.88
IR 34	135	6.7	2.5	1.7	2.68	3.94	1.47	1.58	0.68	2.15	32.1
IR 50	110	6.4	1.9	1.5	3.37	4.26	1.27	2.25	0.79	1.42	22.2

SF, Superfine ; F, Fine ; Cm, Common; *LS, Long Slender; SS, Short slender; MS, Medium Slender; LB Long Bold; SB, Short Bold;

Classification as per: Ram-iah	Bala-sub-ra-manian*	Sow-bhagya *et al***	G. T. °O	Cooking time (o.t) min	Elongation ratio L Cookked / L Raw	Elonga-tion index L:B Cooked / L:B Raw	L:T cooked / L:T raw	Linear elo-ngation Bread-thwise ex-pansion (Le) / (Be)	Linear elongatcn Thickness wise expan-sion (Le) / (Te)	Le:Be / Le:Te	Swelling ratio (v/v)	Propor-tinate change (Li/Bi-LoBo) / Lo/Bo
13	14	15	16	17	18	19	20	21	22	23	24	25
SB	Cm	Cs	65.3	19.0	1.60	1.11	1.03	1.29	1.13	1 14	342	0.55
SB	Cm	Cs	67.3	17.5	1.70	1.26	1.03	2.28	1.22	1.87	300	0.55
SB	Cm	Cs	67.0	17.5	1.61	1.14	1.09	1.44	1.30	1.11	300	0.52
LS	SF	Cs	73 8	17.0	1.46	1.03	0.81	1.01	0 58	1 67	262	0.39
MS	F	Cm	73.1	15.5	1.46	1.04	0.92	1.07	0 72	1.49	300	0 15
MS	F	F	64 9	15.0	1.52	1.08	0.97	1.30	0 91	1.43	300	0.44
SB	Cm	Cs	63.3	19.0	1.61	1.30	1.07	2.11	1 19	1 77	357	0 35
SB	Cm	Cs	65.4	19.5	1.70	1.25	1.16	1.71	1.49	1.15	277	0.29
SB	Cm	Cs	71.3	17.0	1.64	1.09	1.23	1.22	0.95	1.28	400	0.41
SB	Cm	Cs	70.9	22.5	1.51	1.14	0.97	1.59	0.87	1.83	334	0.45
SB	Cm	Cs	66.9	18.0	1.55	1.15	1.09	1.27	1.32	0.96	271	0.60
SB	Cm	Cs	65.6	17.5	1.55	1.13	1.06	1.45	1.16	1.25	314	0.39
MS	F	Cm	71.0	23.0	1.61	1.03	1.03	1.06	1.08	0.98	357	0.31
LS	SE	SF	74.5	17.5	1.52	1.03	1.03	1.28	0.84	1.52	314	0.20
LS	SF	F	73.7	17.5	1.51	1.07	0.98	1.11	0.94	1.18	291	0.33
SB	Cm	Cs	70 3	21.0	1.52	1.22	0.96	1.43	0.66	2.17	343	0.44
SB	Cm	Cs	71.3	23.0	1.66	1.33	1.06	2.75	1.12	2.46	357	0.48
MS	F	Cm	65.7	15.0	1.51	1.04	0.94	1.15	0.89	1.29	300	0.43
SB	F	Cm	71.9	17.0	1.60	1.28	0.95	2.45	0.87	2.82	300	0.28
SB	Cm	F	72.2	17.5	1.62	1.23	1.14	2.04	0.94	2.17	386	0.50
SB	Cm	F	71.3	17.5	1.66	1.17	1.26	1.61	0.90	1.79	342	0.46
SB	Cm	Cm	72.7	21.5	1.64	1.14	1.03	1.45	1.02	1.42	386	0.54
SB	Cm	Cm	74.3	15.0	1.61	1.24	1.16	2.02	1.23	1.64	257	0.44
LB	F	Cs	64.5	17.0	1.61	1.22	1.10	1.91	1.30	1.47	286	0.44
LS	SF	SF	72.7	16.5	1.24	0 89	0.74	1.20	0.75	1.60	271	-0.11

** 10w/L (mg/cm) 23.0, Superfine (SF); <23.0 – 27.0, fine (F); 27.1 – 32.0, Common cm); > 32.0, Coarse (cs)

Table 2. Classification of Tamil Nadu rices based on L : B : T ratio

Slender (L : B : T <2)	IET 4786, IR 50, ADT 35, CR 224
ediun	IET 4722, ASD 15, ADT 36, PY 1, W. Ponr
L : B : T (1.99 to 1.50)	IR 35, IR 20, ACM 5
Bold (L : B : T >1.49)	Ponni, CO 37, Kannagi, IET 1444, ADT 33
	CO 42, NLR 9672, ADT 34, CO 40, TKM 9, ADT 31
	CO 25, CR 1009

1982). The GT is found to correlate with thickness (r=-0.413*), L : B (r = 0.438*). L:T (r=0.504*) and L:B:T (r=0.475*). Though the GT seems to be the major determinant of a particular cultivar for its suitability for processing (Beachel and Stansel, 1963; Perdon and Juliano, 1975,), this characteristic itself is not strictly variety-specific, for it may vary by several degrees within a single variety. This is because, a high ambient temperature during grain development in rice results in its having a higher GT and **vice versa** (Juliano et al., 1969; Resurreccion **et al.**, 1977).

(iii) Cooking characteristics :

The o. t. ranged from 15.0 to 23.0 min; ASD 15 and IR 20 had a shorter cooking time of 15 min; CO 42, 22.5 min and IET 1722 and NR 9672 had 23 min. Cooking time is not a sensitive test of rice quality as it is directly related with the thickness and more so with the surface area of the rice (Bhattacharya and Sowbhagya, 1971). In this study, the o. t. is positively related only with the thickness (r=0.432*) and not with the L, B, L:B, L:T, L:B:T. This indicates that if a particular variety is milled more, its cooking time will be less and by this way all varieties can be made to have an identical cooking time and samples of the same variety to have different cooking times depending upon the extent of milling. Cooking time is marginally more in stored when compared to fresh rice. Moreover, cooking time is directly related with the degree and duration of heat treatment during parboiling (Pillaiyar and Mohandoss, 1981 B; 1981C) Bhattacharya and Sowbhagya (1971) have conclusively proved that water uptake by rice during cooking is primarily related to the surface area of rice, and is generally unrelated to its other physicochemical and quality characteristics. Further, it had been shown that when rice is cooked optimally, all varieties show a nearly constant water uptake of about 2.35 (Bhattcharya and Sowbhagya, 1971). This parameter though appears to be influenced to a very small degree by the protein content and GT of sample, the effects are very small. Protein content itself varies much with the environment and cultural practices; even, as high as, 6% variation in plotein content has been reported. Protein content is higher in cases of low plant densities (De Datta **et al.**, 1972). It also increases with better water management and weed control (Gomez and De Datta, 1975). Additional nitrogen application particularly heading stage always increases protein content. High solar radiation during grain development reduces protein content, whereas the increase is mean temperature increase the protein content in **japonica** variety and not in case of **indica** variety (Resurreccion **et al.**, 1977).

iv) Swelling ratio

The swelling ratio of the varieties studied ranged from 2.57-4.00. Earlier workers (Sanjiva Rao **et al.**, 1952) considered that a large swelling number as a conclusive test of good cooking quality; but considering the foregoing discussions, it is not so American workers (Halick and Keneaster, 1956; Batcher et al., 1957) could not find so a definite correation between volume expansion and Cooking quality of rice. In this study it was observed that the o. t. and swelling ratio were positively correlated with each other. The swelling ratio expressed negative correlations with L, L:B, L:T and L:B:T but did not correlate with other quality attributes like elongation ratio and elongation index. In case of parboiled rice also, the swelling ratio did not relate with any of the properties but only with its cooking time (Pillaiyar, 1983 unpublished) and the latter exhibited a positive relation with the temperature and duration of parboiling (Pillaiyar and Mohan doss, 1981 A, 1981 B). Water uptake during cooking did not correlate either with the rice quality type or the total or insoluble amylose content (Sowbhagya **et al.**, 1984). Even though the swelling ratio of cooked raw CO 25 (3.57) and CO 40 (4.00) is more than IET 4786 (3.14) and IR 20 (2.57), only the latter two raw rices are mostly preferred. This indicates that there seems to be no relation between swelling ratio and preference ratings of cooked rice. As the swelling ratio does not have any relation with any of the intrinsic quality characteristics of rice, determination of this parameter can as well be dispensed with in rice quality studies.

Table 3. GT Grouping of Tamil Nadu rices

Low (58-70°C)	CO 25, IR 34, ASD 15, ADT 31, CO 37, IET 1444, PY 1, TKM 9, ADT 34
Intermediate	CR 1009, CO 42, IET 1722, CO 40, W. Ponni
(70.1 to 74°C)	NLR 9672, ACM 5, Ponni, Kannagi, IR 50, ADT36, CR 224, ADT 3?
High (above 74°C)	IR 20, IET 4786

v) Elongation ratio, elongation index, proportionate change and other parameters of cooking quality

Linear elongation without girthwise expansion is considered a highly desirable trait in rice quality. Of all the quality attributes, kernel elongation appears to be the only character that is predominantly governed by non-aditive gene action (Indian Agricultural Research Institute, 1980). This is most significant in breeders point of view. In the International Co-operative test on grain elongation of milled rice during cooking it was found that the elongation ratio provided more consistent results than elongation index (Juliano and Perez, 1984). Among the varieties studied, IR 50 had the least elongation ratio (1.24) and elongation index (0.89) because of its high girthwise expansion during cooking. The L:T cooked/L:T raw for this variety is also very low (0.74). ADT 35 and ADT 36 had an elongation ratio of less than 1.5 and others more than 1.5 but within 1.70. The elongation index of the varieties studied is very narrow (1.03-1.33); same is the case with L:T cooked/L:T raw values. It would be surprising to note that Nga Kywe (Burma) with a L:B ratio of 1.9 has an elongation ratio and index of 2.26 and 1.83 and Basmati 370 (Pakistan) with an L:B ratio of 3.7 has an elongation ratio and index of 2.16 and 1.65 respectively (Juliano and Perez, 1984). Though varieties like Basmati 370, Sabarmati and Pusa 33 had 'very high' kernel elongation with a proportionate change of >1.0 (Indian Agricultural Research Institute, 1980) none of the varieties studied exhibited 'very high' or

Table 4. Classification based on proportionate change

Degree of kernel elongation	Proportionate change	Varieties
Very high	≥ 1.0	Nil
High	0.99–0.70	Nil
Medium	0.69–0.40	TKM 9, ADT 31, ADT 33, KANNAGI, ADT 34, PONNI, NLR 9672, W. PONNI, CO 42, ASD 15, CR 1009, IR 20, IR 34, PY 1, CO 40
Low	0.38–0.10	IET 1444, ADT 35, CO 25, CR 224, IET 1722, CO 37, ACM 5, IET 4786, ADT 36
Poor	≤0.10	IR 50

even 'high' degree of grain elongation. IR 50 can be rated 'poor' and other varieties as 'medium and 'low' in quality based on the proportionate change (Table 4).

The exact nature of grain elongation is not fully understood. Elongation presumably results from the failure of the endosperm cell walls of some varieties in the direction favouring elongation in contrast to the tendency of other varieties to expand girthwise (Sood et al., 1979; International Rice Research Institute, 1980). The composition of endosperm cell walls in selected elongating and nonelongating rices is similar (Pascual and Juliano, 1983). As against nearly equidistant penta-or hexagonal cells arranged in bee-comb fashion in the elongation types, the cells were found to be long, rectangular and arranged radially in columns extending from the centre to the periphery in the breadthwise swelling types (Indian Agricultural Research Institute, 1980). Grouping of rices based on $\frac{Le}{Be}$, $\frac{Le}{Te}$ and $\frac{Le:Be}{Le:Te}$ has also been attempted. Though these parameters offer comparatively wide range of values (1.01 to 2.75, 0.58 to 1.49 and 0.96 to 2.82 respectively) than elongation index, elongation ratio, $\frac{L:B \text{ cooked}}{L:B \text{ raw}}$ and $\frac{L:T \text{ cooked}}{L:T: \text{ raw}}$ values, varieties with discrete size and shape are getting grouped together and hence these parameters are not of much use.

Elongation ratio correlated positively with the breadth, thickness $\frac{Le}{Be}$ and negatively with L:B, L:T, L:B:T and $\frac{L:B}{L:T}$. On the other hand elongation index correlated with B : T and $\frac{Le:Be}{Le:Te}$ also. Considering the existence of a high correlation among elongation ratio and elongation index and $\frac{L:B \text{ cooked}}{L:T \text{ raw}}$ the elongation ratio can be considered as an index of cooking quality in classifying rice varieties grown in Tamil Nadu. Further, its determination is sample as it involves the measurement of the length only. The disquieting feature here is that though this attribute has negative correlation with the kernel length, it is not significant. On the other hand its significant positive relationship with the breadth and thickness and the high negative correlations with the L : B , L : B : T ratios indicate that the cells arranged from the centre to periphery of the kernels exert much influence on the linear elongation. Such an obscure observation needs further confirmation with histological studies. The negative correlation of swelling ratio with the length, L : B, L:T and L : B : T ratios also lends support to this observation.

Close scrutiny of the data on elongation ratio and other properties studies indicates that the most preferred varieties of Tamil Nadu like ET 4786, Ponni, W. Ponni and IR 20 do not possess the desired cooking qualities. Same is the case with the other high yielding varieties like IR

50, CR 1009, ADT 35, ADT 36 and ACM 3. IET 4786, IR50 and ADT 35 though classified as long slender/ superfine do not possess the desired cooking characteristics. Taking into consideration of all these aspects, systematic work on developing varieties possessing a combination of traits like high yield, longer grain (L : B > 3), white pericarp and high elongation ratio (>2) is considered necessary for a predominantly rice consuming state like Tamil Nadu.

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